Energy Technical Report
Honolulu High-Capacity Transit Corridor Project

November 22, 2006

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City and County of Honolulu
and
Federal Transit Administration

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Acronyms Used in this Document

AA	Alternatives Analysis
BTU	British Thermal Unit
DP	Development Plan
DTS	Department of Transportation Services
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FTA	U.S. Federal Transit Administration
MBTUs	Million British Thermal Units
MPG	Miles Per Gallon
OMPO	Oʻahu Metropolitan Planning Organization
ORTP	Oʻahu Regional Transportation Plan
SUV	Sport Utility Vehicle
TSM	Transportation System Management
UH	University of Hawaiʻi
USDOE	U.S. Department of Energy
VMT	Vehicle Miles Traveled

The City and County of Honolulu Department of Transportation Services (DTS), in coordination with the U.S. Department of Transportation Federal Transit Administration (FTA), is preparing an Alternatives Analysis (AA) and an Environmental Impact Statement (EIS) to evaluate alternatives that would provide high-capacity transit service on Oʻahu.

Energy is consumed during the construction and operation of transportation projects. It is used during construction to manufacture materials, transport materials, and operate construction machinery. Energy used during project operation includes fuel consumed by vehicles in the project area, electricity used to power transit vehicles, and a negligible amount of energy for signals, lighting and maintenance.

Total transportation energy demand for transit and highway vehicles would be lowest for the Fixed Guideway and Transportation System Management (TSM) Alternatives and highest for the Managed Lane Alternative (Table S-1).

Table S-1. Summary of Transportation Energy Demand by Alternative

Alternative	Energy Consumption (MBTUs)[1]
Alternative 1: No Build Alternative	
No Build Alternative	92,310
Alternative 2: TSM Alternative	
TSM Alternative	91,600
Alternative 3: Managed Lane Alternative	
Two-direction Option	94,860
Reversible Option	95,360
Alternative 4: Fixed Guideway Alternative (range)	
Minimum	91,200
Maximum	92,100

[1] MBTUs = Million British Thermal Units

Construction of the Managed Lane Alternative would require between 2,990,000 and 4,160,000 million British Thermal Units (BTUs) of energy. Construction of the Fixed Guideway Alternative would require between 3,700,000 and 4,900,000 million BTUs of energy.

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The City and County of Honolulu Department of Transportation Services (DTS), in coordination with the U.S. Department of Transportation Federal Transit Administration (FTA), has carried out an Alternatives Analysis (AA) to evaluate alternatives that would provide high-capacity transit service on Oʻahu. The primary project study area is the travel corridor between Kapolei and the University of Hawaiʻi at Mānoa (UH Mānoa) (Figure 1-1). This corridor includes the majority of housing and employment on Oʻahu. The east-west length of the corridor is approximately 23 miles. The north-south width of the corridor is at most four miles, as much of the corridor is bounded by the Koʻolau and Waiʻanae Mountain Ranges to the north and the Pacific Ocean to the south.

Figure 1-1. Project Vicinity

Project Description

Description of the Study Corridor

The study corridor extends from Kapolei in the west (Waiʻanae or ʻEwa direction) to the University of Hawaiʻi at Mānoa (UH Mānoa) in the east (Koko Head direction), and is confined by the Waiʻanae and Koʻolau Mountain Ranges to the north (mauka direction) and the Pacific Ocean to the south (makai direction). Between Pearl City and ʻAiea, the corridor's width is less than one mile between the Pacific Ocean and the base of the Koʻolau Mountains.

The General Plan for the City and County of Honolulu directs future population and employment growth to the 'Ewa and Primary Urban Center (PUC) Development Plan areas and the Central O'ahu Sustainable Communities Plan area. The largest increases in population and employment are projected in the 'Ewa, Waipahu, Downtown, and Kaka'ako districts, which are all located in the corridor (Figure 1-2).
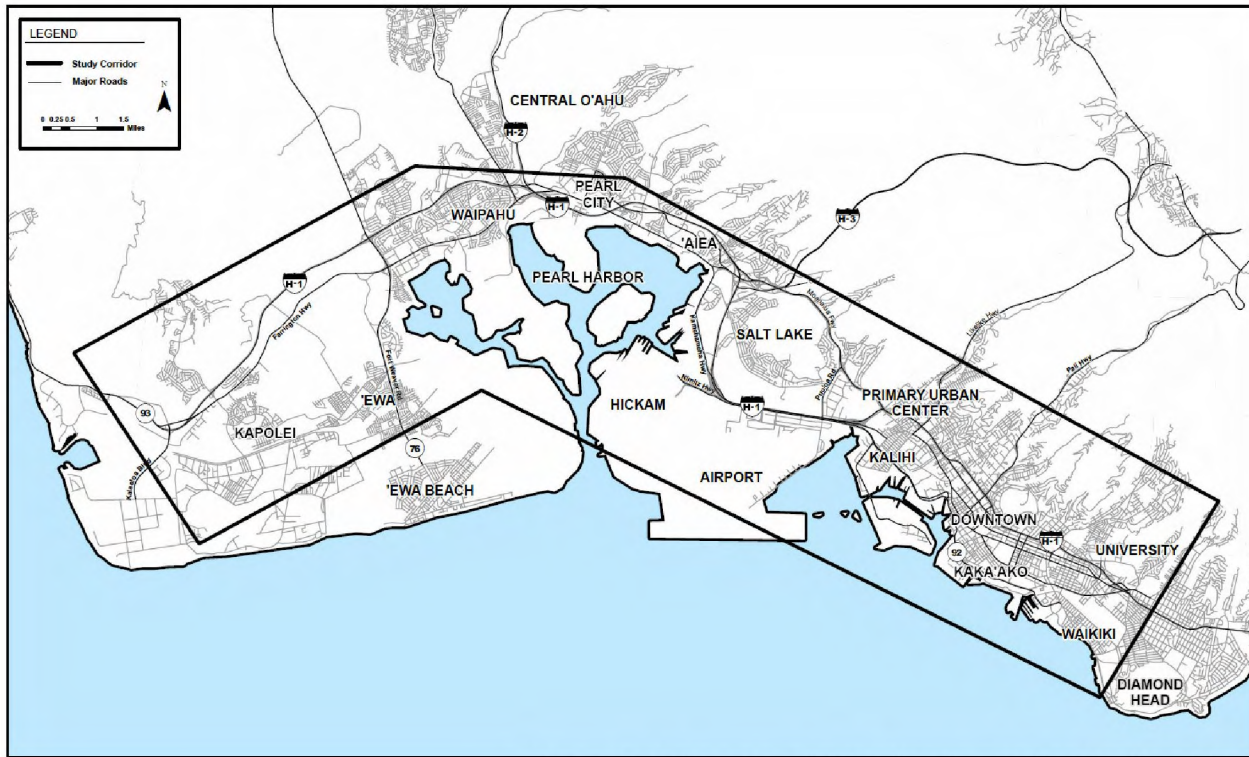

Figure 1-2. Areas and Districts in the Study Corridor

Currently, 63 percent of the 876,200 people living on O'ahu and 81 percent of the 499,300 jobs on O'ahu are located within the study corridor. By 2030 this distribution will increase to 69 percent of the population and 84 percent of the employment as development continues to be concentrated into the PUC and 'Ewa Development Plan areas. Kapolei is the center of the 'Ewa Development Plan area and has been designated as O'ahu's "second city." City and State government offices have opened in Kapolei, and the University of Hawai'i is developing a master plan for a new West O'ahu campus there. The Kalaeloa Community Development District (formerly known as Barbers Point Naval Air Station) covers 3,700 acres adjacent to Kapolei and is planned for redevelopment. The Department of Hawaiian Home Lands is also a major landowner in the area and is planning for residential and retail development. In addition, developers have several proposals to continue the construction of residential subdivisions.

Continuing Koko Head, the corridor follows Farrington and Kamehameha Highways through a mixture of low-density commercial and residential development. This part of the corridor passes through the makai portion of the Central O'ahu Sustainable Communities Plan area.

Farther Koko Head, the corridor enters the PUC Development Plan area, which is bounded by commercial and residential densities that begin to increase in the vicinity of Aloha Stadium. The Pearl Harbor Naval Reserve, Hickam Air Force Base, and Honolulu International Airport border

the corridor on the makai side. Military and civilian housing are the dominant land uses mauka of Interstate Route H-1 (H-1 Freeway), with a concentration of high-density housing along Salt Lake Boulevard.

As the corridor continues Koko Head across Moanalua Stream, the land use becomes increasingly dense. Industrial and port land uses dominate along the harbor, shifting to primarily commercial uses along Dillingham Boulevard, a mixture of residential and commercial uses along North King Street, and primarily residential use mauka of the H-1 Freeway.

Koko Head of Nuʻuanu Stream, the corridor continues through Chinatown and Downtown. The Chinatown and Downtown areas, with 62,300 jobs, have the highest employment density in the corridor. The Kakaʻako and Ala Moana neighborhoods, comprised historically of low-rise industrial and commercial uses, are being revitalized with several high-rise residential towers currently under construction. Ala Moana Center, both a major transit hub and shopping destination, is served by more than 2,000 weekday bus trips and visited by more than 56 million shoppers annually.

The corridor continues to Waikīkī and through the McCully neighborhood to UH Mānoa. Today, Waikīkī has more than 20,000 residents and provides more than 44,000 jobs. It is one of the densest tourist areas in the world, serving approximately 72,000 visitors daily (DBEDT, 2003). UH Mānoa is the other major destination at the Koko Head end of the corridor. It has an enrollment of more than 20,000 students and approximately 6,000 staff (UH, 2005). Approximately 60 percent of students do not live within walking distance of campus (UH, 2002) and must travel by vehicle or transit to attend classes.

Alternatives under Consideration

Four alternatives will be evaluated in the Alternatives Analysis (AA) report. They were developed through a screening process that considered alternatives identified through previous transit studies, a field review of the study corridor, an analysis of current housing and employment data for the corridor, a literature review of technology modes, work completed by the Oʻahu Metropolitan Planning Organization (OMPO) for its Draft 2030 Regional Transportation Plan, and public and agency comments received during a formal project scoping process held in accordance with requirements of the National Environmental Policy Act (NEPA) and the Hawaiʻi EIS Law (Chapter 343). The four alternatives are described in detail in the *Honolulu High-Capacity Transit Corridor Project Alternatives Analysis Definition of Alternatives Report* (DTS, 2006a). The alternatives identified for evaluation in the AA report are as follows:

- No Build Alternative
- Transportation System Management Alternative
- Managed Lane Alternative
- Fixed Guideway Alternative

Alternative 1: No Build

The No Build Alternative includes existing transit and highway facilities and committed transportation projects anticipated to be operational by 2030. Committed transportation projects are those programmed in the Oʻahu 2030 Regional Transportation Plan prepared by OMPO. The

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committed highway elements of the No Build Alternative will also be included in the build alternatives (discussed below).

The No Build Alternative's transit component would include an increase in fleet size to accommodate growth in population, while allowing service frequencies to remain the same as today. The specific number of buses, as well as required ancillary facilities, will be determined during the preparation of the AA.

Alternative 2: Transportation System Management

The Transportation System Management (TSM) Alternative would provide an enhanced bus system based on a hub-and-spoke route network and relatively low-cost capital improvements on selected roadway facilities to give priority to buses. The TSM Alternative would include the same committed highway projects as assumed for the No Build Alternative.

Alternative 3: Managed Lane

The Managed Lane Alternative would include construction of a two-lane, grade-separated facility between Waipahu and Downtown Honolulu for use by buses, paratransit vehicles, and vanpool vehicles. High-occupancy vehicles (HOV) and toll-paying, single-occupant vehicles also would be allowed to use the facility provided that sufficient capacity would be available to maintain free-flow speeds for buses and the above-noted paratransit and vanpool vehicles. Variable pricing strategies for single-occupant vehicles would be implemented to ensure free-flow speeds for high-occupancy vehicles.

Intermediate bus access points would be provided in the vicinity of Aloha Stadium and Middle Street. Buses using the managed lane facility would be restructured and enhanced, providing additional service between Kapolei and other points 'Ewa of the PUC, as well as Downtown Honolulu and UH Mānoa.

Alternative 4: Fixed Guideway

The Fixed Guideway Alternative would include the construction and operation of a fixed-guideway transit system between Kapolei and UH Mānoa. The system could use any fixed-guideway transit technology approved by FTA and meeting performance requirements, and could be automated or employ drivers.

Station and supporting facility locations are currently being identified and would include a vehicle maintenance facility and park-and-ride lots. Bus service would be reconfigured to bring riders on local buses to nearby fixed-guideway transit stations.

Although this alternative would be designed to be within existing street or highway rights-of-way as much as possible, property acquisition in various locations is expected to be necessary. Future extensions of the system to Central Oʻahu, East Honolulu, or within the corridor are possible, but are not being addressed in detail at present.

A broad range of modal technologies were considered for application to the Fixed Guideway Alternative, including light rail transit, personal rapid transit, automated people mover, monorail, magnetic levitation (maglev), commuter rail, and emerging technologies still in the developmental stage. Several technologies were selected in an earlier screening process and will be considered as possible options for the fixed-guideway technology. Technologies that were not carried forward from the screening process include personal rapid transit, commuter rail, and

the emerging technologies. The screening process is documented in the *Honolulu High-Capacity Transit Corridor Project Screening Report* (DTS, 2006b).

The study corridor for the Fixed Guideway Alternative will be evaluated in five sections to simplify analysis and impact evaluation in the AA process and report. In general, each alignment under consideration within each of the five sections may be combined with any alignment in the adjacent sections.

Each alignment has distinctive characteristics and environmental impacts and provides different service options. Therefore, each alignment will be evaluated individually and compared to the other alignments in each section. The sections that will be evaluated and the alignments being evaluated for each section are listed in Table 1-1. In addition to the combinations of alignments, a shorter 20-mile Alignment also was evaluated.

Table 1-1. Fixed Guideway Alternative Analysis Sections and Alignments

Section	Alignments Being Considered
I. Kapolei to Fort Weaver Road	Kamokila Boulevard/Farrington Highway
	Kapolei Parkway/North-South Road
	Saratoga Avenue/North-South Road
	Geiger Road/Fort Weaver Road
II. Fort Weaver Road to Aloha Stadium	Farrington Highway/Kamehameha Highway
III. Aloha Stadium to Middle Street	Salt Lake Boulevard
	Makai of the Airport Viaduct
	Mauka of the Airport Viaduct
	Aolele Street
IV. Middle Street to Iwilei	North King Street
	Dillingham Boulevard
V. Iwilei to UH Mānoa	Hotel Street/Kawaiahaʻo Street/Kapiʻolani Boulevard with or without Waikīkī Branch
	Hotel Street/Waimanu Street/Kapiʻolani Boulevard with or without Waikīkī Branch
	Nimitz Highway/Queen Street/Kapiʻolani Boulevard with or without Waikīkī Branch
	Nimitz Highway/Halekauwila Street/Kapiʻolani Boulevard with or without Waikīkī Branch
	Beretania Street/South King Street
	Waikīkī Branch

Project Purpose

The purpose of the Honolulu High-Capacity Transit Corridor Project is to provide improved mobility for persons traveling in the highly congested east-west transportation corridor between Kapolei and UH Mānoa, confined by the Waiʻanae and Koʻolau Mountain Ranges to the north and the Pacific Ocean to the south. The project would provide faster, more reliable public transportation services in the corridor than those currently operating in mixed-flow traffic. The project would also provide an alternative to private automobile travel and improve linkages

between Kapolei, the urban core, UH Mānoa, Waikīkī, and urban areas in-between. Implementation of the project, in conjunction with other improvements included in the 2030 Oʻahu Regional Transportation Plan (ORTP), would moderate anticipated traffic congestion in the corridor. The project also supports the goals of the Oʻahu General Plan and the ORTP by serving areas designated for urban growth.

Project Area Needs

Improved Mobility for Travelers Facing Increasingly Severe Traffic Congestion

The existing transportation infrastructure in the corridor between Kapolei and UH Mānoa is overburdened handling current levels of travel demand. Motorists experience substantial traffic congestion and delay at most times of the day during both the weekdays and weekends. Average weekday peak-period speeds on the H-1 Freeway are currently less than 20 miles per hour (mph) in many places and will degrade even further by 2030. Transit vehicles are caught in the same congestion. Travelers on Oʻahu's roadways currently experience 51,000 vehicle hours of delay, a measure of how much time is lost daily by travelers stuck in traffic, on a typical weekday. This is projected to increase to more than 71,000 daily vehicle hours of delay by 2030, assuming implementation of all of the planned improvements listed in the ORTP (except for a fixed guideway system). Without these improvements, the ORTP indicates that daily vehicle-hours of delay could increase to as much as 326,000 vehicle hours.

Current a.m. peak-period travel times for motorists from West Oʻahu to Downtown average between 45 and 81 minutes. By 2030, after including all of the planned roadway improvements in the ORTP, this travel time is projected to increase to between 53 and 83 minutes. Average bus speeds in the system have been decreasing steadily as congestion has increased. Currently, express bus travel times from ʻEwa Beach to Downtown range from 45 to 76 minutes and local bus travel times from ʻEwa Beach to Downtown range from 65 to 110 minutes during the peak period. By 2030, these travel times are projected to increase by 20 percent on an average weekday. Within the urban core, most major arterial streets will experience increasing peak-period congestion, including Ala Moana Boulevard, Dillingham Boulevard, Kalākaua Avenue, Kapiʻolani Boulevard, King Street, and Nimitz Highway. Expansion of the roadway system between Kapolei and UH Mānoa is constrained by physical barriers and by dense urban neighborhoods that abut many existing roadways. Given the current and increasing levels of congestion, a need exists to offer an alternative way to travel within the corridor independent of current and projected highway congestion.

Improved Transportation System Reliability

As roadways become more congested, they become more susceptible to substantial delays caused by incidents, such as traffic accidents or heavy rain. Even a single driver unexpectedly braking can have a ripple effect delaying hundreds of cars. Because of the operating conditions in the study corridor, current travel times are not reliable for either transit or automobile trips. To get to their destination on time, travelers must allow extra time in their schedules to account for the uncertainty of travel time. This is inefficient and results in lost productivity. Because the bus system primarily operates in mixed-traffic, transit users experience the same level of travel time uncertainty as automobile users. A need exists to reduce transit travel times and provide a more reliable transit system.

Accessibility to New Development in 'Ewa/Kapolei/Makakilo as a Way of Supporting Policy to Develop the Area as a Second Urban Center

The General Plan for the City and County of Honolulu projects the highest population growth rates for the island will occur in the 'Ewa Development Plan area (comprised of the 'Ewa, Kapolei, and Makakilo communities), which is expected to grow by 170 percent between 2000 and 2030. This growth represents nearly 50 percent of the total growth projected for the entire island. The Wai'anae, Wahiawā, North Shore, Windward, Waimānalo, and East Honolulu areas will have population growth of between zero and 16 percent because of this policy, which keeps the country "country." Kapolei, which is developing as a "second city" to Downtown Honolulu, is projected to grow by nearly 600 percent to 81,100 people, the 'Ewa neighborhood by 100 percent, and Makakilo by 125 percent between 2000 and 2030. Accessibility to the overall 'Ewa Development Plan area is currently severely impaired by the congested roadway network, which will only get worse in the future. This area is less likely to develop as planned unless it is accessible to Downtown and other parts of O'ahu; therefore, the 'Ewa, Kapolei, and Makakilo area needs improved accessibility to support its future growth as planned.

Improved Transportation Equity for All Travelers

Many lower-income and minority workers live in the corridor outside of the urban core and commute to work in the PUC Development Plan area. Many lower-income workers also rely on transit because of its affordability. In addition, daily parking costs in Downtown Honolulu are among the highest in the United States (Colliers, 2005), further limiting this population's access to Downtown. Improvements to transit capacity and reliability will serve all transportation system users, including low-income and under-represented populations.

Project Schedule

Projects developed through the FTA New Starts process progress through many stages from system planning to operation of the project. The Honolulu High-Capacity Transit Corridor Project is currently in the Alternatives Analysis phase, which includes defining and evaluating specific alternatives to address the purpose of and needs for the project as discussed in this chapter. The anticipated project development schedule for completion of the 20-mile Alignment is shown in Figure 1-3.
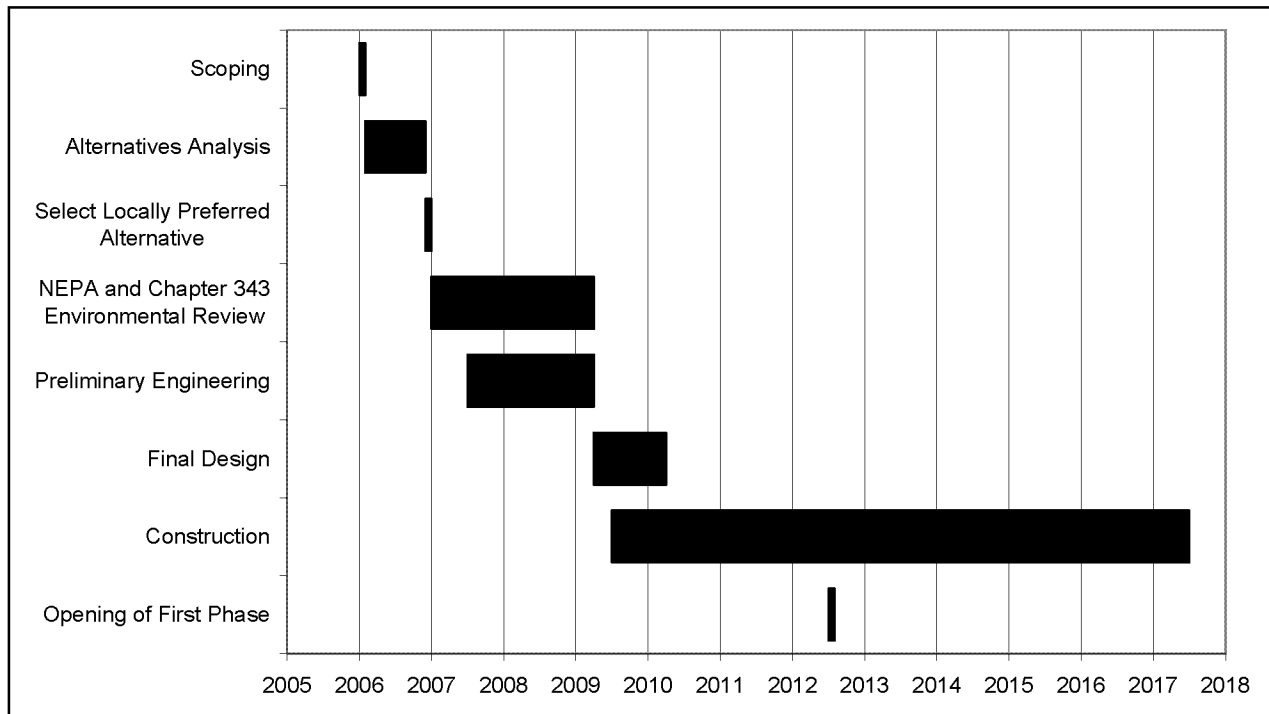
Figure 1-3. Project Schedule

This report estimates the quantity of energy that would be consumed with the construction and operation of each alternative.

Energy is consumed during the construction and operation of transportation projects. It is used during construction to manufacture materials, transport materials, and operate construction machinery. Energy used during project operation includes fuel consumed by vehicles in the project area, electricity used to power transit vehicles, and a negligible amount of energy for signals, lighting and maintenance. Energy consumption depends on the number of vehicle miles traveled (VMT) and travel conditions such as vehicle type, speed of travel, roadway grade, and pavement type. For gasoline-powered vehicles, speed is the most important factor affecting energy consumption.

The transportation sector is very energy-dependent upon petroleum. Transportation within the United States consumes approximately 27,000 Tera British Thermal Units (Tera BTUs) of petroleum per year and is expected to increase to 44,000 Tera BTUs by 2025 (USDOE, 2005). Gasoline consumption in the United States is projected to increase an average of 2 percent per year over the next two decades.

Energy Units

Energy is commonly measured in British Thermal Units (BTUs). Because these are relatively small units, energy is often reported in million BTUs (MBTUs). Even larger amounts of energy are reported in Tera BTUs (million MBTUs). One gallon of gasoline contains approximately 0.13 MBTUs. As a point of reference, the caloric intake for an adult person is approximately three MBTUs per year (2,000 calories = .008 MBTUs).

Energy Consumed by Transit Operations

Fixed-guideway high-capacity transit systems directly consume energy for propulsion and indirectly through energy lost during transmission from the energy generation site to the transit vehicles.

Transit energy consumption depends on several variables, including: vehicle size, type, weight, and efficiency; passenger-related load factors; system grade; spacing of stations; operational issues such as acceleration, deceleration, and top and average speeds; throttle positions; horsepower to weight ratio; and deadheading requirements. These variables result in a wide range of operational energy requirements.

Previous studies have documented energy consumption of between 50,000 and 100,000 BTUs per vehicle-mile of service (Caltrans, 1983). The average energy consumption for all rail transit operations in the United States is 72,000 BTUs per vehicle-mile of service (USDOE, 2004). Indirect energy consumption through losses due to generation, transmission, and conversion of alternating to direct current averages 27 percent.

Energy Consumed by Roadway Vehicles

Vehicle fuel consumption is the primary component of operating costs paid by individual users of transportation facilities. Road geometry, surface conditions, and traffic flows substantially affect the operating efficiency of vehicles, and consequently of total energy consumption.

For the various alternatives, fuel consumption rates can be differentiated by comparing changes in traffic operations, as measured by VMT and changes in traffic speed. Fuel consumption is proportional to distance traveled, and decreases as speed increases up to about 30 miles per hour (mph). Fuel consumption is fairly flat between about 30 mph and 60 mph and increases as speed increases above that point (USDOE, 2004) (Figure 2-1).

Source: Department of Energy, 2004
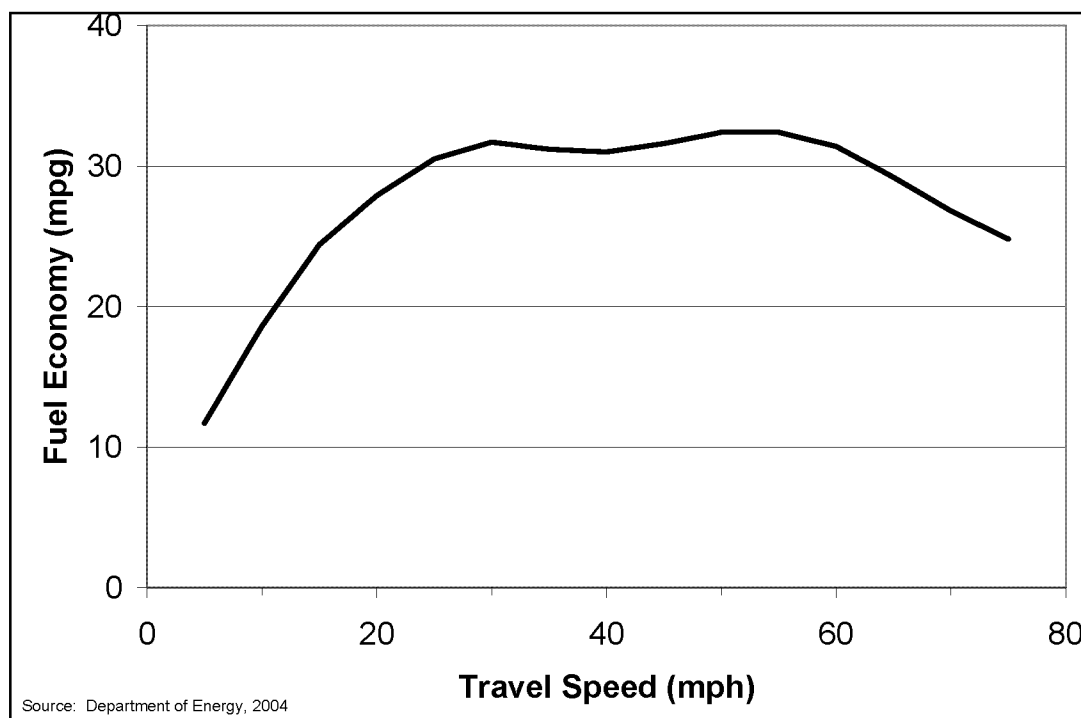
Figure 2-1. Average Automobile Fuel Consumption Compared to Speed

Since the early 1970s, the U.S Environmental Protection Agency (EPA) has analyzed automobile and light truck fuel economy data. Fuel economy continues to be a major area of public and policy interest for several reasons, including the following:

- Fuel economy is directly related to carbon dioxide emissions, the most prevalent pollutant associated with global warming. Light vehicles (automobiles and light trucks) contribute about 20 percent of all U.S. carbon dioxide emissions.
- Light vehicles account for approximately 40 percent of all U.S. oil consumption. Crude oil, from which nearly all light vehicle fuels are made, is a finite natural resource.

- Fuel economy is directly related to the cost of fueling a vehicle and is of greater interest when oil and gasoline prices rise, as has happened recently.

Fleet-wide improvement in new light vehicle fuel economy occurred from the middle 1970s through the late 1980s, but has consistently fallen since then. Since 1988, average new light vehicle fuel economy has declined 1.9 miles per gallon (mpg), or more than 7 percent. This decline has resulted from the increase in the light truck market share and in general vehicle weight and performance (USEPA, 2003). Viewed separately, the average fuel economy for new cars has been essentially flat over the last 15 years, only varying from 27.6 mpg to 28.6 mpg. Similarly, the average fuel economy for new light trucks has been largely unchanged for the past 20 years, ranging from 20.1 mpg to 21.6 mpg (USEPA, 2003).

The increasing market share of light trucks, which have lower average fuel economy than cars, accounts for much of the decline in fuel economy of the overall new light vehicle fleet. Recent growth in the light truck market has resulted from the popularity of sport utility vehicles (SUVs). SUV sales have increased by more than a factor of 10 – from 2 percent of the overall market in 1975 to 20 percent of the market in 2000. Over the same period, the market share for vans doubled from 4.5 to 9 percent, and the market for pickup trucks grew from 13 to 17 percent. For model year 2000, cars average 28.1 mpg, vans 22.5 mpg, pickups 20.1 mpg, and SUVs 20.0 mpg (USEPA, 2003). Because the mixture of vehicles in use includes both new and older vehicles, the average fuel consumption for the on-road fleet was 20.8 mpg in 2000 (USDOE, 2005).

More efficient technologies, such as engines with more valves and sophisticated fuel injection systems and transmissions with lockup torque converters and extra gears, continue to penetrate the new light vehicle fleet. The trend has clearly been to apply these new technologies to increase average new vehicle weight, power, and performance while maintaining fuel economy. The U.S. Department of Energy (USDOE) projects this trend will continue, with average new car horsepower increasing by 27 percent by 2025, but with little change in average fuel economy (Figure 2-2).

Nationwide trends over the last 10 to 15 years reflect a lack of progress in fuel economy. New technologies used in hybrid vehicles change the horizon for fuel economy projections and indicate that improvements on the order of 100 to 200 percent may be possible (USEPA, 2003). Recent developments suggest various potential pathways for possible future fleetwide fuel economy improvements, including voluntary commitments by some manufacturers to improve the fuel economy of certain portions of their fleets by as much as 25 percent. At this point, the USDOE projects that average fuel economy for the total on-road fleet will change little over the next 20 years. Rather, technology improvements will generally result in a larger, more powerful vehicle fleet rather than a more fuel-efficient one.
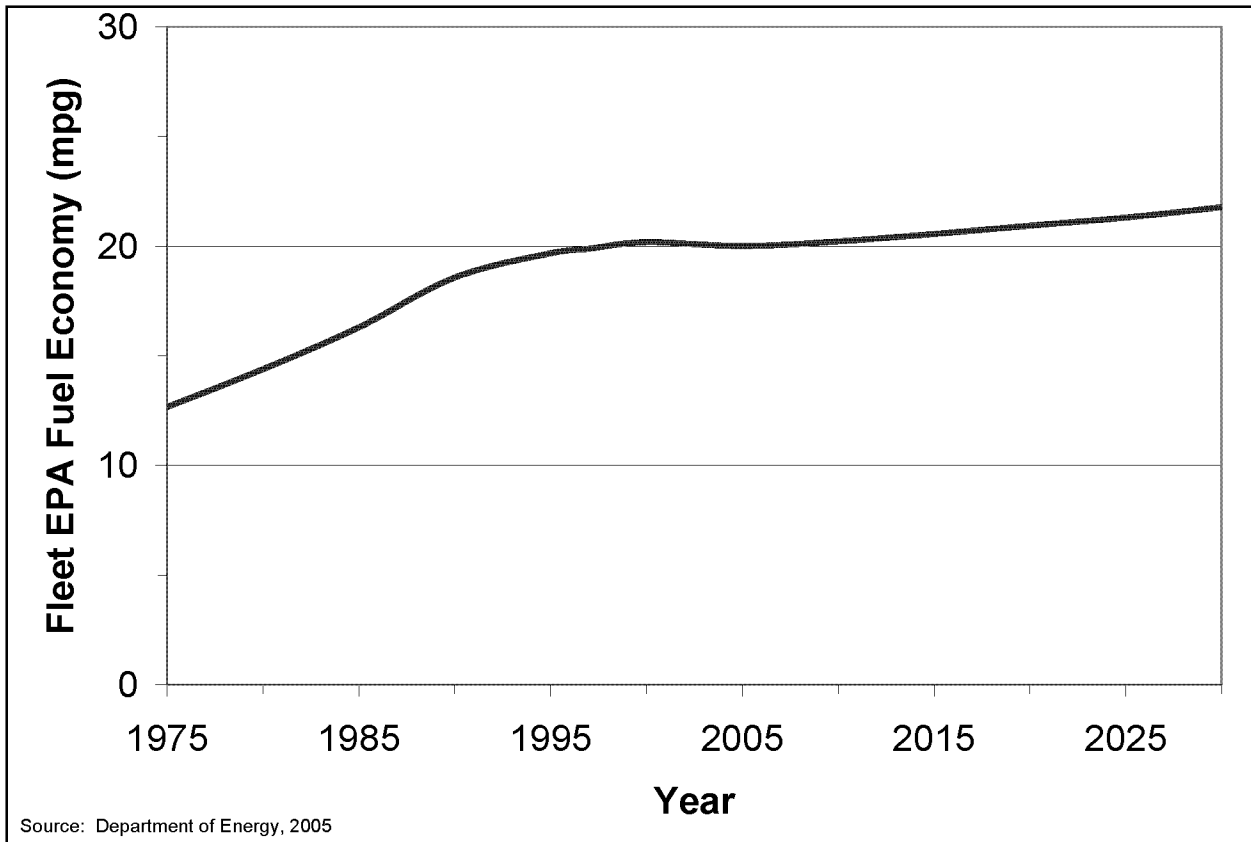
Figure 2-2. Nationwide Fuel Economy Trend

Energy Consumed During Construction

Energy is consumed both directly and indirectly during project construction. Direct energy consumption includes the energy used to operate construction machinery, provide construction lighting, and produce and transport materials such as asphalt. Indirect energy consumption includes activities such as manufacturing and maintaining construction equipment, and the energy consumed by workers commuting to the project site. Because direct one-time energy consumption for roadway projects is much greater than indirect energy consumption and indirect energy consumption is difficult to define, only direct energy consumption is considered in this evaluation. The energy consumption required to complete a project is proportional to the project size and the nature of the work involved.

The operational energy consumption analysis within the project study area was based on the transportation analyses prepared for this project and proposed transit operations. Net changes in overall transportation energy use in the study area are assessed using daily vehicle miles traveled (VMT) and speed values calculated from the transportation demand forecasting model for the study area. Energy consumed by electrically powered transit operations for the Fixed Guideway Alternative also are calculated. Indirect energy required to transport fuel and materials to Hawai'i has been omitted, as it would tend to comprise the same proportion of energy consumption for each alternative.

The alternatives are compared based on daily differences in fuel consumed by traveling vehicles (USDOT, 1980). This value is approximate for each alternative and does not include several factors, such as energy consumption for facility maintenance and signal operation; however, this value provides an appropriate basis for comparison among the alternatives. FTA estimates energy consumption at 6,233 BTUs per vehicle-mile of travel (FTA, 2006). This estimate is typical of steel-wheel transit systems. Monorail has somewhat higher energy consumption because of additional rolling friction associated with its rubber-tire design. Maglev also has been demonstrated to consume more energy than steel-wheel rail (Vuchic, 2002).

Estimates of operational energy requirements for the fixed-guideway system is based on calculations of direct propulsion energy and indirect energy needs, such as energy lost during transmission from the energy generation site to the transit system vehicles. Propulsion energy consumption for a light-rail, high-capacity transit system typically ranges between 50,000 and 100,000 BTUs per vehicle-mile (Caltrans, 1983). The FTA estimated energy consumption of 77,739 BTUs per vehicle-mile of travel (FTA, 2006), which is slightly higher than the average reported by the U.S. Department of Energy, was used for this calculation. Because fixed-guideway transit would operate in two-vehicle trains, actual energy consumption would be less than this estimate as a result of reduced wind friction during operation. Energy consumption has been annualized using a factor of 308 for consistency with the _Honolulu High-Capacity Transit Corridor Project Transportation Impacts Results Report._

Construction energy consumption was estimated for each alternative by estimating the energy consumed based on construction of major elements of the project. An approximate construction energy consumption factor for roadway elements on a structure ranges between 220,000 and 275,000 million BTUs per mile of structure, depending on its width. Placement of roadway surface increases the energy required by an additional 3,000 to 4,000 million BTUs per mile of roadway.

For at-grade high-capacity transit systems, a construction energy estimate of 20,000 million BTUs per track mile constructed was used (Caltrans, 1983). This figure includes installation of track and power systems for the system. A construction energy estimate of 150,000 million BTUs per track mile constructed is added for elevated portions of the alignment to account for the energy required to construct the elevated support structure.

Total energy consumption in the State of Hawai'i was 324 Terra BTUs in 2004 (DBEDT, 2006). Approximately 90 percent of energy consumed in Hawai'i is derived from petroleum. Transportation accounts for approximately 34 percent of all energy consumption in Hawai'i (DBEDT, 2006). In 2004, 292 million gallons of gasoline (38 Terra BTUs) were consumed by motor vehicles on the Island of O'ahu (Figure 4-1). Gasoline consumption increased approximately 1.5 percent annually on O'ahu between 1990 and 2004. Gasoline represents the largest segment of transportation energy consumption, closely followed by aviation fuel, then by diesel.
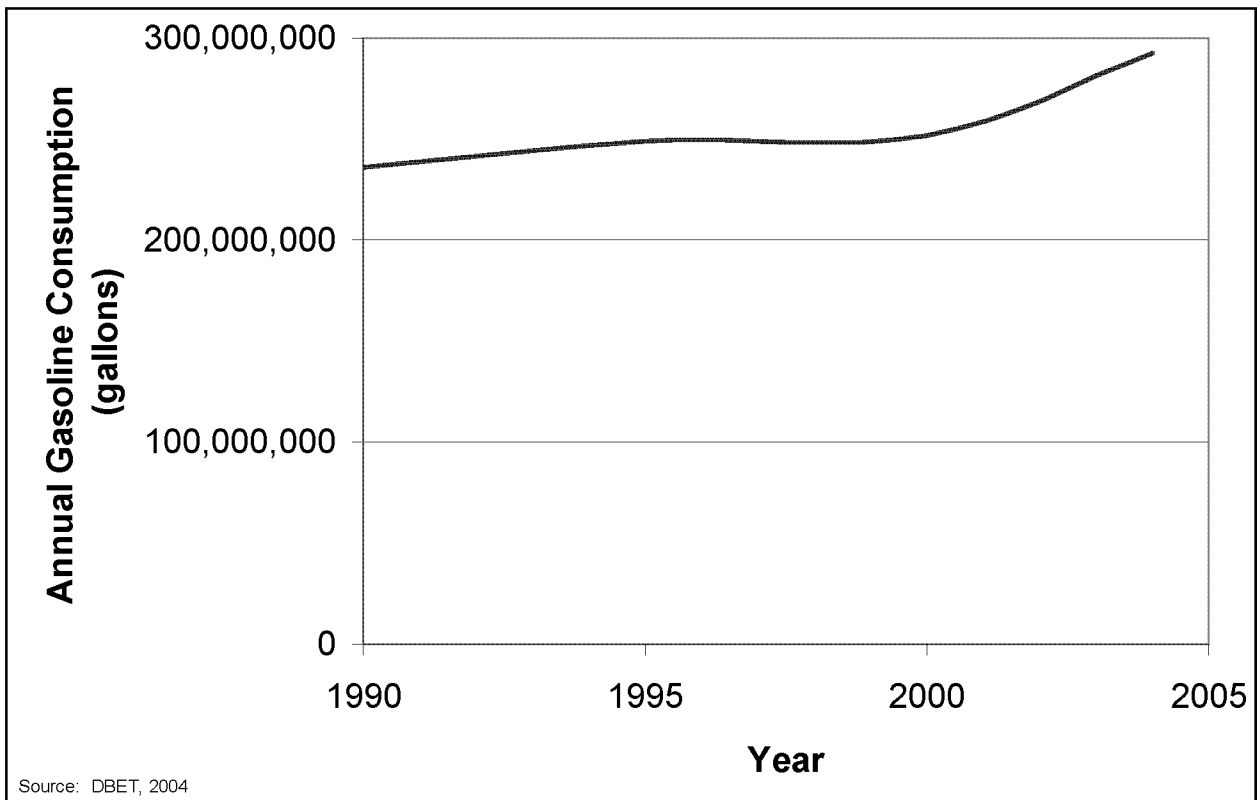

Source: DBET, 2004

Figure 4-1. Island of O'ahu Gasoline Consumption Trend

Transportation modeling results for 2005 show that approximately 12 million vehicle miles are traveled daily on O'ahu. This results in a daily consumption of approximately 567,000 gallons of gasoline with an energy content of 74,000 million BTUs.

Alternative 1: No Build

While the No Build Alternative (see Chapter 1) assumes completion of projects defined in the 2030 Oʻahu Regional Transportation Plan (ORTP), no construction would be undertaken as part of this project. Impacts associated with development of the individual projects listed in the RTP are not detailed in this evaluation because the projects will undergo planning and environmental review as part of their individual project development process.

Transportation energy consumption for the No Build Alternative would include motor vehicle fuel consumption islandwide (Table 5-1). Energy would be consumed during construction of elements of the No Build Alternative; however, that energy would be consumed under all of the other alternatives as well and will be considered in the environmental analysis of the individual projects.

Table 5-1. Average Daily Islandwide Motor Vehicle Energy Consumption

Alternative	Vehicle Miles Traveled	Average Speed	Gasoline Consumption (Gallons)	Energy Consumption (MBTUs)[1]
2005 Existing Energy Consumption				
2005 Existing Conditions	11,818,700	43.6	566,700	73,670
Alternative 1: No Build Alternative				
No Build Alternative	14,809,900	42.6	710,100	92,310
Alternative 2: TSM Alternative				
TSM Alternative	14,696,300	42.7	704,600	91,600
Alternative 3: Managed Lane Alternative				
Two-direction Option	15,220,000	42.3	729,700	94,860
Reversible Option	15,299,500	42.1	733,600	95,360
Alternative 4: Fixed Guideway Alternative (range)				
Minimum	14,334,500	43.1	687,300	89,350
Maximum	14,410,900	43.1	690,900	89,820

[1]MBTUs = million BTUs
Note: Average energy consumption calculated at 6,233 BTU per vehicle mile

Alternative 2: Transportation System Management

Transportation energy consumption for the TSM Alternative would include motor vehicle fuel consumption islandwide (Table 5-1). Consumption would be somewhat less than for the No Build Alternative, as more trips would be taken by bus than under the No Build Alternative.

Energy would be consumed during construction of elements of the TSM Alternative; however, the level of construction under this alternative would not be substantially greater than for the No Build Alternative; therefore, the construction energy consumption would not be substantially greater.

Alternative 3: Managed Lane

Long-term Impacts

Additional vehicle trips would occur with the Managed Lane Alternative. Vehicle-miles traveled would be greater than for any other alternative, resulting in greater fuel consumption than with any other alternative. The Reversible Option would result in greater energy consumption than the Two-direction Option.

Construction Impacts

Construction of the 14.9-mile, two-direction option would consume approximately 4,157,000 million BTUs of energy, while construction of the 13.4-mile reversible option would consume approximately 2,988,000 million BTUs of energy.

Alternative 4: Fixed Guideway

Long-term Impacts

The Fixed Guideway Alternative would result in reduced gasoline consumption compared to all other build alternatives (Table 5-1). In addition to motor vehicle fuel consumption, electricity would be consumed to power the fixed-guideway transit system. The amount of electricity required would depend on the length of the alignment and the number of daily transit-vehicle trips (Table 5-2). Energy consumption would be proportional to the length of the alignment in each section. Total daily transportation energy consumption would be less than for the No Build and Managed Lane Alternatives and similar to the TSM Alternative (Table 5-3). The annualized values are provided in Table 5-4.

Table 5-2. Average Daily Energy Consumption of Fixed Guideway Transit System

Alternative	Length (miles)	Daily Vehicle Trips[1]	Energy Consumption (MBTUs)[2]
I. Kapolei to Fort Weaver Road			
Kamokila Boulevard/Farrington Highway	6.1	1,040	490
Kapolei Parkway/North-South Road	7.2	1,040	580
Saratoga Avenue/North-South Road	9.0	1,040	730
Geiger Road/Fort Weaver Road	8.9	1,040	720
II. Fort Weaver Road to Aloha Stadium			
Farrington Highway/Kamehameha Highway	6.7	1,040	540
III. Aloha Stadium to Middle Street			
Salt Lake Boulevard	4.8	1,040	390
Mauka of the Airport Viaduct	5.2	1,040	420
Makai of the Airport Viaduct	5.2	1,040	420
Aolele Street	5.4	1,040	440
IV. Middle Street to Iwilei			
North King Street	1.7	1,040	140
Dillingham Boulevard	1.8	1,040	150
V. Iwilei to UH Mānoa			
Beretania Street/South King Street	4.0	1,040	320
Hotel Street/Kawaiahaʻo Street/Kapiʻolani Boulevard	4.6	1,040	370
Hotel Street/Waimanu Street/Kapiʻolani Boulevard	4.6	1,040	370
Nimitz Highway/Queen Street /Kapiʻolani Boulevard	4.6	1,040	370
Nimitz Highway/Halekauwila Street/Kapiʻolani Boulevard	4.7	1,040	380
Waikīkī Spur	1.5	520	60

[1]Daily vehicle trips calculated as per car for two-car trains operating in both directions between 4 a.m. and 12 a.m.
[2]MBTUs = million BTUs
Note: Average energy consumption calculated at 77,739 BTU per rail-vehicle mile

Table 5-3. Average Daily Islandwide Transportation Energy Consumption

Alternative	Vehicle Miles Traveled (roadway)	Average Speed (roadway)	Energy Consumption (MBTUs)[1]
Alternative 1: 2030 No Build			
No Build Alternative	14,809,900	42.6	92,310
Alternative 2: 2030 Transportation Systems Management			
TSM Alternative	14,696,300	42.7	91,600
Alternative 3: 2030 Managed Lane			
Two-direction Option	15,220,000	42.3	94,860
Reversible Option	15,299,500	42.1	95,360
Alternative 4: 2030 Fixed Guideway (range)			
Minimum	14,334,500	43.1	91,200
Maximum	14,410,900	43.1	92,100

[1]MBTUs = million BTUs
Note: Includes both roadway and rail transit energy consumption

Table 5-4. 2030 Annual Islandwide Transportation Energy Consumption

Alternative	Annual Vehicle Miles Traveled (roadway)	Energy Consumption (MBTUs)[1]
Alternative 1: 2030 No Build		
No Build Alternative	4,561,449,200	28,431,480
Alternative 2: 2030 Transportation Systems Management		
TSM Alternative	4,526,460,400	28,212,800
Alternative 3: 2030 Managed Lane		
Two-direction Option	4,687,760,000	29,216,880
Reversible Option	4,712,246,000	29,370,880
Alternative 4: 2030 Fixed Guideway (range)		
Minimum	4,415,026,000	28,089,600
Maximum	4,438,557,200	28,366,800

[1]MBTUs = million BTUs

Note: Includes both roadway and rail transit energy consumption

Construction Impacts

Construction of the Fixed Guideway Alternative would require energy. Depending on the alignments selected, guideway and track construction would require between approximately 3,700,000 and 4,900,000 million BTUs. At-grade construction would require less energy than construction of elevated structures or tunnels. Table 5-5 shows estimated construction energy requirements for the various alignment options.

Table 5-5. Construction Energy Consumption for Fixed Guideway Transit

Alternative	Length (miles)	Energy Consumption (MBTUs)[1]
I. Kapolei to Fort Weaver Road		
Kamokila Boulevard/Farrington Highway	6.1	1,037,000
Kapolei Parkway/North-South Road	7.2	1,224,000
Saratoga Avenue/North-South Road	9.0	1,230,000
Geiger Road/Fort Weaver Road	8.9	1,513,000
II. Fort Weaver Road to Aloha Stadium		
Farrington Highway/Kamehameha Highway	6.7	1,139,000
III. Aloha Stadium to Middle Street		
Salt Lake Boulevard	4.8	816,000
Mauka of the Airport Viaduct	5.2	584,000
Makai of the Airport Viaduct	5.2	884,000
Aolele Street	5.4	918,000
IV. Middle Street to Iwilei		
North King Street	1.7	289,000
Dillingham Boulevard	1.8	306,000
V. Iwilei to UH Mānoa		
Beretania Street/South King Street	4.0	680,000
Hotel Street/Kawaiahaʻo Street/Kapiʻolani Boulevard	4.6	782,000
Hotel Street/Waimanu/Kapiʻolani Boulevard	4.6	782,000
Nimitz Highway/Queen Street /Kapiʻolani Boulevard	4.6	782,000
Nimitz Highway/Halekauwila Street/Kapiʻolani Boulevard	4.7	799,000
Waikīkī Spur	1.5	199,000

[1]MBTU = million BTU

Secondary and Cumulative

Transportation is only one sector of the total energy demand for Oʻahu. The various transportation alternatives would have little effect on the energy demand in other sectors.

If the Managed Lane Alternative is selected, transportation control measures to reduce traffic volumes and congestion should be considered to decrease energy consumption.

If the Fixed Guideway Alternative is selected, it would result in a decrease in long-term energy use compared to the No Build Alternative; therefore, no mitigation would be required. Any transportation control measures to reduce traffic volumes and congestion would also decrease energy consumption.

Measures to maintain roadway speeds as well as construction practices that reduce energy consumption could reduce energy demand during construction.

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